Original Research Article

**Disaster Preparedness Among Public School Teachers in**

**Manay Davao Oriental: A Post Hoc Comparison**

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ABSTRACT

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| Disaster preparedness in schools is essential for ensuring the safety and well-being of students and staff in times of emergency. Teachers play a critical role in executing disaster response plans and sharing knowledge related to disaster readiness. This study used a descriptive-comparative study employing a T-test for Independent Samples and Anova tools. 251 public teachers were invited to answer an adapted survey questionnaire in Manay District, Division of Davao Oriental . Teachers' disaster preparedness levels were rated on a 5-point Likert scale, with a higher score indicating greater preparedness. The study reveals that public school teachers in Manay District, Division of Davao Oriental demonstrate a high level of disaster preparedness overall, with a mean score of 3.71. Teachers strongly recognize the importance of sharing knowledge and experiences related to disasters but show only moderate participation in disaster awareness campaigns. While no significant differences were found in disaster preparedness based on sex, age and years of service were found to be influential factors. Middle-aged teachers (31-40 years) and those with more than ten years of experience exhibited higher levels of preparedness, suggesting that life experience and professional tenure contribute to disaster readiness in educational settings. |

*Keywords*: Disaster Preparedness, Public School Teachers, Post Hoc Comparison

1. INTRODUCTION

Disaster preparedness among teachers is a critical element in ensuring the safety and well-being of students during emergencies. As frontliners in the school setting, teachers play a pivotal role in establishing a safe and responsive learning environment. Their readiness and ability to act during disasters can significantly mitigate risks and potentially save lives. Effective disaster preparedness involves equipping teachers with the knowledge, skills, and tools necessary to respond to a variety of emergency situations—be it natural disasters such as typhoons, earthquakes, and floods, or human-induced incidents like fires or chemical spills. This includes familiarity with evacuation procedures, first aid techniques, emergency communication protocols, and post-disaster recovery strategies.

Globally, teachers are viewed as role models and trusted figures. Their capacity to remain calm, decisive, and organized during crises can help maintain order, reduce panic, and facilitate a safe evacuation or emergency response. As such, cultivating a culture of preparedness among teachers not only ensures the safety of students but also fosters school-wide resilience and continuity in the face of disaster. According to Bihari et al. (2022), disasters have become more frequent and intense due to climate change and rapid urbanization—underscoring the growing necessity for comprehensive disaster risk reduction (DRR) strategies within educational institutions.

The United Nations Office for Disaster Risk Reduction (2020) reported that from 2000 to 2019, over 7,348 major disaster events resulted in 1.23 million fatalities, affected 4.2 billion individuals, and caused an estimated $2.97 trillion in economic losses worldwide. These alarming statistics highlight the urgent need for improved disaster preparedness at all levels—especially within schools, which are often vulnerable due to population density and limited resources. A key challenge remains the lack of awareness and proactive planning at both individual and institutional levels. Many school personnel—including teachers—lack adequate training in how to respond before, during, and after major disasters such as typhoons, earthquakes, and flash floods.

In Pakistan, for instance, Shah et al. (2020) emphasized that teachers’ disaster preparedness is foundational to school resilience. They noted the need for comprehensive training that enables educators to recognize hazards, implement safety protocols, and respond effectively to emergencies. Such preparedness includes mastery of first aid, evacuation drills, and psychological first aid to address the emotional needs of students. Likewise, Adepoju et al. (2022) stressed the importance of integrating disaster education into the curriculum, which empowers students and staff alike to respond with confidence during emergencies.

However, disaster management often faces systemic issues. One critical concern is the overreliance on non-governmental organizations (NGOs) for disaster response. While NGOs bring expertise and resources, this dependence can reflect significant gaps in government-led preparedness and institutional capacity (Khaledi et al., 2023).

Even in highly developed countries like Japan, which has integrated disaster risk education into both formal and informal learning systems, challenges persist due to the country’s frequent exposure to natural calamities. Haraguchi (2020) noted that continuous adaptation of preparedness strategies is essential to cope with evolving risks. In contrast, India’s Bihar region, frequently affected by flash floods, struggles with early warning systems and communication mechanisms necessary for effective response (Banzal, 2022).

In the Philippines, one of the most disaster-prone countries in the world, the educational sector has repeatedly been impacted by typhoons and earthquakes. The aftermath of Typhoon Yolanda (Haiyan) in 2013 revealed glaring gaps in school-level disaster readiness. Gaudiel (2023) observed disparities in preparedness among school administrators based on age and experience, indicating the need for standardized training across all educational levels. Islam et al. (2022) identified administrative overload and poor compliance as key challenges to implementing effective DRR protocols. Meanwhile, Manayan (2024) highlighted inadequate flood control and drainage systems in Davao region, calling attention to infrastructure issues that hinder school and community resilience.

Teachers’ preparedness extends beyond the classroom—it plays a vital role in enhancing the broader community’s readiness. As respected community figures, teachers can influence not only students but also families by disseminating crucial disaster preparedness information. Their training in emergency response enables them to provide emotional support, coordinate with first responders, and maintain order during crises. When teachers are knowledgeable and confident in their roles, this has a ripple effect—promoting a culture of safety and awareness across the community.

Moreover, with the rapid advancement of technology and access to disaster-related data, education and awareness remain the most effective tools to prevent or mitigate the impacts of disasters. As such, this study highlights the importance of teacher education and preparedness in disaster risk reduction (DRR), especially in vulnerable areas. Schools must integrate structured DRR programs and provide ongoing training to build teacher confidence and capability in emergency response. In light of these challenges, this study investigates disaster preparedness among teachers and its influence on teaching and learning during face-to-face sessions—particularly during the rainy season. Given the increasing frequency and severity of disasters, the role of educators in disaster preparedness must be strengthened through systematic planning, infrastructure improvement, capacity-building, and policy support. By equipping teachers with the tools and training needed to respond effectively, schools can enhance resilience and reduce the adverse effects of disasters on education and community life.

**1.1 Statement of the Problem**

This study was conducted to determine the level of disaster preparedness of public school teachers in Manay District, Division of Davao Oriental utilizing a post hoc comparison. Hence, this study sought answers to the following specific questions:

1. What is the demographic profile of the respondents in terms of:

1.1 sex,

1.2 age, and

1.3 Number of years in service?

2. What is the level of disaster preparedness of teachers?

3. Is there a significant difference between public school teachers when grouped according to their demographic profile, utilizing a post hoc comparison?

2. methodology

**2.1 Research Design**

The research design to be used in this study was a quantitative research method using a descriptive-comparative design in which the data and findings were interpreted statistically. According to Farsi et al. (2022), research was valid when a conclusion was accurate or true, and the research design was the conceptual blueprint within which research was conducted. When designing research, it was necessary to recognize the type of evidence required to answer the research question reasonably. Descriptive-comparative research studies attempt to determine, clarify, or describe. Additionally, the researcher used a descriptive-comparative, non-experimental research strategy to appropriately address the study objectives.

**2.2 Research Respondents**

The respondents of the study were the selected teachers in the different public elementary schools in Manay District, Division of Davao Oriental. Universal sampling was used to select the respondents. There were 215 respondents in this study. The teachers served at least three years in public schools. This study was conducted from the school year 2024 to 2025. The researcher employed a stratified random sampling technique for this study, which involves choosing a sample based on population characteristics and study objectives (Howell et al., 2020). This type of sampling can be particularly beneficial when there is a need to reach a proportional sample quickly. The public school teachers were the targeted respondents for the researchers, so the researcher had established criteria for selecting that only teachers from public schools to be surveyed. The researcher was confident that by establishing criteria, the research objectives were most effectively achieved.

**2.3 Research Instrument**

The primary data collection tool for this study consisted of researcher-made survey questionnaires designed to assess the level of disaster preparedness among public school teachers in Manay District, Division of Davao Oriental. The instruments were developed with reference to established theoretical frameworks, relevant scholarly literature, and previous research on disaster risk reduction, emergency response, and school safety protocols. The questionnaire included items related to preparedness knowledge, skills, response strategies, and perceived school readiness for disaster events.

To ensure the instrument's validity and alignment with the study’s objectives, it underwent face and content validation by a panel of experts in Disaster Risk Reduction and Management (DRRM), Educational Leadership, and Curriculum Studies. Revisions were made in accordance with the panel’s suggestions to enhance the instrument’s clarity, coherence, and content relevance.

To test the reliability of the instrument, a pilot study was conducted involving 30 public school teachers from a nearby district not included in the main study. The results yielded high internal consistency, with a Cronbach’s Alpha of 0.938 for the overall Disaster Preparedness scale, indicating strong reliability and suitability of the instrument for the main data collection.

**2.4 Data Gathering Procedure**

# Data collection for this study followed a systematic and ethically sound procedure. The researcher first obtained an endorsement from the Dean of the Graduate School and secured ethical clearance from the institution’s Ethics Review Committee. A formal request was then submitted to the Office of the Schools Division Superintendent of the Division of Davao Oriental. Upon approval, an endorsement letter was issued to the School Heads of the public schools in Manay District to authorize the conduct of the research.

# To ensure the reliability and clarity of the research instruments, a pilot test was conducted involving teachers from a neighboring district not included in the main study. Based on the pilot test results, necessary revisions were made to improve the final version of the survey questionnaires that assessed disaster preparedness among teachers.

# The finalized instruments were then administered to 143 public school teacher-respondents in Manay District using a universal sampling approach. Each respondent was oriented on the objectives of the study and provided with clear instructions for accurately completing the questionnaire. The completed surveys were personally retrieved by the researcher and subsequently submitted to a professional statistician for encoding, tabulation, and statistical analysis.

# 2.5 Data Analysis

The statistical tools mentioned below are the essential tools that the researcher used to analyze and interpret the results of the data gathered for this study:

Mean. This is a descriptive statistical tool that the researcher employed to determine the level of the variables being studied.

Comparing Means. A T-test for independent samples and ANOVA analysis were utilized in this study. This statistical tool is used to test whether there is a significant difference in the readiness among public school teachers when grouped according to sex, age, and number of years in teaching service.

3. results and discussion

**3.1 Demographic Profile of the Respondents**

Table 1. *Demographic Profile of the Respondents*

|  |  |  |
| --- | --- | --- |
| Demographic Profile | Frequency | Percentage |
| **Sex** |  |  |
| Male | 105 | 58.17 |
| Female | 146 | 41.83 |
| **Total** | **251** | **100** |
| **Age** |  |  |
| Age 21-30 | 94 | 37.45 |
| Age 31-40 | 50 | 19.92 |
| 41 and above | 107 | 42.63 |
| **Total** | **251** | **100** |
| **Years in service** |  |  |
| Less than 5 years | 90 | 35.86 |
| 5-10 years | 120 | 47.81 |
| 10 years above | 41 | 16.33 |
| **Total** | **251** | **100** |

Table 1 shows the results and a descriptive value of each demographic profile. There are 146, which is 58. 17 percent are female, 105 are male, and 41.83 percent of respondents in this study. For the age of the respondents, 37.45 percent are aged 21-30, or there are 94 respondents; 19.92 percent are aged 31-40, which means there are 50 respondents, and the remaining 42.63 percent are ages 41 and above, and there are 107 respondents. For the years of experience, 35.86 percent, or 90 respondents, have less than five years of experience, 120, or 47.81 percent, already have 5 to 10 years of experience, and 41, or 16.33 percent, already have ten years of experience.

**3.2 Level of Disaster Preparedness of Teachers in Public Schools**

Table 2. *Level of Disaster Preparedness of Teachers in Public Schools*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Disaster Preparedness** | | **Mean** | | **Description** |
| 1. I know when a disaster will happen. | 3.60 | | High | |
| 2. I know disasters cannot be prevented. | 3.81 | | High | |
| 3. I have attended disaster risk reduction and management training or seminars. | 3.48 | | High | |
| 4. I know the government is ready to provide assistance after a disaster. | 3.76 | | High | |
| 5. I know the importance of sharing knowledge and experiences of disaster. | 4.22 | | Very High | |
| 6. I know the government will provide enough facilities after disaster and we will not face any problems. | 3.68 | | High | |
| 7. I am confident that reconstruction activities can be implemented after a disaster. | 3.52 | | High | |
| 8. I recognize the importance of making conversation about disasters with family members, relatives, neighbor, friends, and colleagues. | 3.90 | | High | |
| 9. I gain enough knowledge about disaster experts who work or conduct activities for disaster risk reduction and management. | 3.86 | | High | |
| 10. I am aware of the shelter areas, evacuation centers and open spaces in case of a disaster. | 3.78 | | High | |
| 11. I am aware of which government office needs to be coordinated with after a disaster. | 3.63 | | High | |
| 12. I am informed about disaster prone areas. | 3.63 | | High | |
| 13 . I am getting enough information about disaster adaptation from non-government organizations (NGO’s). | 3.60 | | High | |
| 14. I have knowledge about an evacuation area during a disaster. | 3.73 | | High | |
| 15. I know the importance of community activities for disaster risk reduction. | 3.76 | | High | |
| 16. I am fully aware and informed about evacuation sy5-10 years and plan in my locality and barangay. | 3.80 | | High | |
| 17. I actively participate in disaster awareness campaigns. | 3.39 | | Moderate | |
| 18. I am aware of the importance of building or infrastructure retrofitting. | 3.71 | | High | |
| 19. I am prepared with emergency kits and bags in case of disaster. | 3.54 | | High | |
| 20. I have a good relationship with my neighbors and community | 3.78 | | High | |
| **Total** | | **3.71** | | **High** |

Table 2 shows that overall, the respondents showed a high level of disaster preparedness, with a mean value of 3.71, which indicates that respondents are often prepared for disasters. Specifically, the highest statement is, “I know the importance of sharing knowledge and experiences of disaster,” with a mean value of 4.22 and a descriptive value of very high, meaning that teachers know how important it is to share information and experiences of disaster. The lowest statement, “I actively participate in disaster awareness campaigns,” has a mean score of 3.39 with a moderate descriptive level. This further suggests that the respondents actively participate in disaster awareness campaigns but only sometimes evident.

The data presented in Table 2 indicates that the teachers, who were the respondents, demonstrated a high level of readiness for disasters, as evidenced by a mean score of 3.71. This suggests that the teachers were well-prepared to respond to and mitigate disasters. Notably, the statement "I know the importance of sharing knowledge and experiences of disaster" received the highest mean value of 4.22, indicating that the teachers acknowledged the importance of sharing information and experiences related to disaster preparedness. On the other hand, the statement "I actively participate in disaster awareness campaigns" received the lowest mean score of 3.39, suggesting a moderate level of engagement in such activities. These results imply that while the teachers recognize the significance of knowledge sharing, there is room for improvement in their active involvement in disaster awareness campaigns.

**3.3 Significant Difference in Disaster Preparedness of Public School Teachers in terms of Sex**

Table 3. *Significant Difference in Disaster Preparedness of Public School Teachers in terms of Sex*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demographic Profile** |  | **Mean** | **Mean Difference** | **t-value** | **Sig. (2-tailed)** |
| **Sex** | **FEMALE** | 3.776 | 0.115 | 1.687 | 0.093 |
|  | **MALE** | 3.661 |  |

As shown in Table 3, the null high hypothesis was not rejected at a p-value of 0.93. Hence, it means that there is no significant difference in the level of disaster preparedness when respondents are grouped according to their sex.

The relationship between gender and disaster preparedness has been a topic of growing interest in the field of emergency management. While some studies have suggested no significant differences in the level of disaster preparedness between men and women, other research has highlighted the unique vulnerabilities and challenges women face in disaster risk reduction.

Existing literature has explored the complex interplay of sociocultural, economic, and biological factors contributing to disaster vulnerability's gendered nature. For instance, studies have shown that underlying gender inequalities, such as limited access to resources and decision-making power, can exacerbate women's susceptibility to the adverse impacts of disasters (Erman et al., 2021)

One study found that in the aftermath of the 2010 Haiti earthquake, women and girls faced significant barriers to accessing essential services and resources, including clean water, healthcare, and transportation (Llorente‐Marrón et al., 2020).

The study of Popovicki (2022) mentioned that the negative results of Serbia's 2014 flooding showed poor management of the response phase, which was made worse by a gender imbalance. We looked into how men and women in Serbia perceived danger and were prepared for these kinds of incidents because of this. In light of the current data, men appeared to be more certain about their capacity to handle flooding and perceived higher individual and household readiness. Women, on the other hand, demonstrated a deeper comprehension of these occurrences. Women exhibited more household-caring attitudes and actions and were more likely to say they would be willing to assist flood victims at reception centers, which may be due to a deeper degree of understanding. The differences in perception also highlight the importance of incorporating diverse perspectives in emergency response planning.

**3.4. Significant Difference in Disaster Preparedness of Public School Teachers in terms of Age**

**Table 4.** *Significant Difference in Disaster Preparedness of Public School Teachers in terms of Age*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demographic Profile** |  | **Mean** | **Df** | **F-value** | **Sig. (2-tailed)** |
| **Age** | 40 and above | 3.647 | 2, 248 | 4.127 | 0.017 |
|  | Age 31-40 | 3.900 |
|  | Age 21-30 | 3.678 |

The analysis is presented in Table 4 is the significant differences in disaster preparedness among public school teachers based on their age group. The results indicate a statistically significant difference, as the F(2, 248) = 4.127, p = 0.017. This suggests that age affects how prepared teachers feel for disaster scenarios. Specifically, the mean disaster preparedness score was highest among teachers aged 31–40 years (M = 3.900), followed by those aged 21–30 years (M = 3.678), and lowest among teachers aged 40 years and above (M = 3.647).

These findings suggest that age contributes to disaster preparedness among educators, with middle-aged teachers exhibiting higher levels of preparedness. This could be attributed to factors such as increased life experience, greater awareness of potential hazards, or a heightened sense of responsibility for student safety. Recent research supports the notion that age influences disaster preparedness, with studies conducted by Ying et al. (2023) finding that older nurses exhibited higher levels of preparedness than their younger counterparts. In a study by Adepoju et al. (2020), who discovered that almost 6 in 10 older minority individuals did not believe they were prepared for disasters. Survival and planning behaviors were favorably correlated with Medicare coverage. In the African American population, survival behaviors were correlated with income level and prior disaster experience. Last, understanding the gaps in disaster preparedness among older minority groups can guide culturally considerate actions to enhance disaster preparedness and recovery.

As stated by Patel et al. (2020), in terms of disaster readiness and response, students are one of the most susceptible subsets of the general population; nonetheless, many colleges still lack policies and planning for disaster preparedness, mitigation, and response. This study examined how students perceived being aware of and prepared for disasters based on their ethnicity and where they resided (on or off campus). A thorough examination of the disaster education literature was undertaken for this study.

**3.5. Significant Difference in Disaster Preparedness of Public School Teachers in terms of Years of Service**

**Table 5.** *Significant Difference in Disaster Preparedness of Public School Teachers in terms of Years of Service*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 5..** *Post Hoc Comparisons - Years in Service* | | | | | | | | | |
|  | |  | | **Mean Difference** | | **SE** | **t** | | **ptukey** |
| 10 years and above |  | (5-10 years) |  | 0.235 |  | 0.098 | 2.386 |  | 0.047 |  |
|  |  | less than 5 years |  | 0.346 |  | 0.102 | 3.380 |  | 0.002 |  |
| (5-10 years) |  | less than 5 years |  | 0.111 |  | 0.076 | 1.463 |  | 0.311 |  |
|  | | | | | | | | | |

The analysis of variance (ANOVA) was conducted to examine the impact of years in service on the variable of interest. The results showed a statistically significant effect of years in service, with an F(2, 248) = 5.714, p = 0.004. This indicates a significant difference in the measured variable across different groups based on years of service. The post hoc Tukey's test further revealed that individuals with less than five years of service exhibited significantly different scores compared to those with 5–10 years and ten years and above. Specifically, there was a significant mean difference of 0.346 (p = 0.002) between the group with less than five years and the group with ten years and above. Similarly, there was a notable mean difference of 0.235 (p = 0.047) between the 5–10 years group and the 10-year and above group. However, the comparison between the 5–10 years group and the group less than five years was not statistically significant, with a mean difference of 0.111 (p = 0.311). These findings suggest that individuals with more experience (10 years and above) may have distinct perceptions or behaviors compared to those with fewer years of service.

Sakurai et al. (2020) studied Japanese elementary school teachers and found that years of teaching experience significantly influenced disaster preparedness levels. Their results showed that teachers with more than 15 years of experience demonstrated higher levels of preparedness, including better knowledge of evacuation procedures and more effective communication strategies during emergencies. This aligns with our finding of a significant difference between teachers with 10 years and above experience and those with less experience.

Similarly, Fernandez (2022) explored the impact of professional experience on teachers' disaster risk reduction (DRR) competencies in the Philippines. Their study revealed that teachers with more years of service showed higher levels of DRR knowledge and skills, particularly in areas of risk assessment and emergency response planning. This supports our observation of differences between the most experienced group and those with fewer years of service.

In a broader educational context, Kraft and Lyon (2024) examined how teachers' effectiveness evolves over their careers. They found that teachers continue to improve their skills beyond the first few years of teaching, with significant gains in effectiveness occurring even after a decade of experience. This trend in general teaching effectiveness could explain our findings of distinct perceptions or behaviors in the group with 10 years and above experience.

Lastly, Sims et al. (2021) meta-analysis on teacher professional development emphasized the importance of experience in shaping teachers' practices and beliefs. They noted that teachers with more years of service tend to have more developed professional networks and a broader repertoire of strategies, which could contribute to different perceptions and behaviors in various aspects of their work, including disaster preparedness.

**5. CONCLUSIONS**

The study reveals that public school teachers in Manay District, Division of Davao Oriental demonstrate a high level of disaster preparedness overall, with a mean score of 3.71. Teachers strongly recognize the importance of sharing knowledge and experiences related to disasters but show only moderate participation in disaster awareness campaigns. While no significant differences were found in disaster preparedness based on sex, age and years of service were found to be influential factors. Middle-aged teachers (31-40 years) and those with more than ten years of experience exhibited higher levels of preparedness, suggesting that life experience and professional tenure contribute to disaster readiness in educational settings.

**6. RECOMMENDATIONS**

The recommendations are categorized based on the mentioned beneficiaries. As per the study's conclusions, the researchers propose the following recommendations:

Initially, the Department of Education officials may develop and implement comprehensive disaster preparedness training programs tailored to different age groups and experience levels of teachers. They may also integrate disaster preparedness into the curriculum and teacher professional development programs.

Next, the school heads may organize regular disaster preparedness drills and simulations in schools. They can also encourage experienced teachers to mentor younger colleagues in disaster preparedness strategies.

Subsequently, teachers may actively participate in disaster awareness campaigns and share knowledge with colleagues and students. They can also seek opportunities for continuous learning about disaster preparedness and risk reduction.

Students should actively engage in school-organized disaster preparedness activities and share their learned knowledge with family and community members, fostering a culture of preparedness.

Parents are encouraged to collaborate with schools on disaster preparedness initiatives, reinforce these lessons at home, and participate in community-wide preparedness efforts, creating a supportive environment for their children's learning.

Community leaders can play a crucial role by partnering with schools to organize community-wide disaster preparedness events and facilitating knowledge sharing between experienced community members and schools, thereby strengthening the overall resilience of the community.

For future researchers, there are several important avenues to explore: investigating the specific factors that contribute to higher disaster preparedness in middle-aged and experienced teachers, exploring effective strategies to increase participation in disaster awareness campaigns among teachers of all age groups and experience levels, and conducting longitudinal studies to track changes in disaster preparedness over teachers' careers. These research directions could provide valuable insights for improving disaster preparedness in educational settings and beyond.

Consent (where ever applicable)

This study was conducted in full compliance with established ethical standards to ensure the protection of participants’ rights, dignity, and overall well-being. Before any data were collected, the researcher obtained all required institutional permissions, including an endorsement from the Dean of the Graduate School and ethical approval from the institution’s Ethics Review Committee. The research process adhered to the ethical framework outlined by Pregoner et al. (2025), in line with current best practices for studies involving human participants in education.

Participation in the study was entirely voluntary. All respondents were clearly informed about the study’s objectives, procedures, and their right to refuse or withdraw from participation at any time without facing any consequences. Informed consent was obtained to confirm that participants understood and willingly agreed to take part in the research. To protect anonymity, no personal identifiers were collected, and all data were handled with strict confidentiality. The gathered information was used solely for academic purposes, ensuring transparency, ethical soundness, and full respect for participant autonomy throughout the study.

Disclaimer (Artificial Intelligence)

The author(s) hereby declare that generative AI technologies have been used during the writing and editing of this manuscript. The details of the AI usage are as follows:

1. Grammarly: Used for grammar and spellchecking, as well as suggestions for improving sentence structure and overall clarity.
2. Quillbot: Employed for paraphrasing and refining sentence flow to enhance readability and coherence.

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